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A THEORY OF NEUROPHYSICS AND QUANTUM NEUROSCIENCE: IMPLICATIONS FOR BRAIN FUNCTION AND THE LIMITS OF CONSCIOUSNESS

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The authors have assumed there are specific temporal patterns of complex electromagnetic fields that can access and affect all levels of brain space. The article presents formulae and results that might reveal the required field configurations to obtain this access and to represent these levels in human consciousness. The frequency for the transition from an imaginary to real solution for the four-dimensional human brain was the wavelength of hydrogen whereas the optimal distance in space was the width of a proton or electron. The time required to expand one Planck's length as inferred by Hubble's constant for the proton was about 1 to 3 ms, the optimal resonant "point duration" of our most bioeffective magnetic fields. Calculations indicated the volume of a proton is equivalent to a tube or string with the radius of Planck's length and the longitudinal length of 10^{25} m (the width of the universe). Solutions from this approach predicted the characteristics of many biological phenomena, seven more "dimensions" of space between Planck's length and the level of the proton, and an inflection point between increments of space and time that corresponded to the distances occupied by chemical bonds. The multiple congruencies of the solutions suggest that brain space could contain

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inordinately large amounts of information reflecting the nature of extraordinarily large increments of space and time.

Keywords quantum neuroscience biophysics, brain, electromagnetic fields, Hubble's constant, Planck's length, proton

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All brain functions and their associated experiences are determined by physical principles. John (1990) hypothesized that the complexity of brain function is derived from a small number of basic algorithms. Nunez (1995), in his chapter "Towards a physics of the neocortex," applied classical electromagnetic theory to describe essential properties within the brain. He showed that the resonant frequency for the human brain, based on its circumference and bulk velocity of action potentials, was within the same frequency range (about 7 Hz) as the intrinsic (Schumann) resonance of the earth itself. Jibu and Yasue (1995) showed that phenomena often reserved for the domain of quantum mechanics were reflected within the characteristics of consciousness.

The authors have studied the effects of complex electromagnetic fields upon organisms in order to understand the functional connections between the organismic, cellular, molecular, and atomic phenomena that are correlated with specific behaviors. Electromagnetic fields are the only stimuli that are easily manipulable experimentally and, because of their penetrability of matter, can produce measurable changes from the level of the atom to the level of the entire organism. Even pharmacological actions and the neurochemical interactions between synapses are ultimately reducible to electromagnetic equivalents. This article presents a perspective that may facilitate the use of electromagnetic fields for understanding the relationships between the different spatial dimensions that define the levels of discourse by which science describes living systems.

BASIC ASSUMPTIONS

The two assumptions that structure determines function and temporal patterns control the dynamics of these functions are fundamental to the organization of human knowledge in general and the pursuit of science specifically. These two assumptions have encouraged the pursuit of the possibility that humans can discern connections and equivalences between levels of discourse. They are, after all, arbitrary divisions of increments of space and time that define the specific sciences. These equivalences and connections do not necessarily require a crude reductionism of biological or psychological processes into

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smaller components. Instead there may exist a central, unifying description or factor to which all levels of discourse are related.

The brain, the classical word for the volume of space and duration of time occupied by specific structures of biological phenomena, has been the focus of neuroscience. However, this volume and its average existence in a human being (about 2 Gigasec) is composed of matter and space. While investigating the fundamental properties of matter and the relationships between space and time, several results emerged that may help reveal the ultimate connection between brain structure and function and how they relate to the intricacies of the physical world.

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SOLUTIONS FOR A FOUR-DIMENSIONAL BRAIN

Brain function occurs within a four-dimensional context involving the three dimensions of space and time or the xt-plane of Euclidian geometry. This concept was first introduced by Hermann Minkowski during the early twentieth century to describe nonliving matter. However, the concept can also be applied to living matter. It is assumed that living matter is simply an emergent process due to specific organizations or configurations of "non"-living matter existing within time.

The meter of "four-dimensional distance" in this xt-plane has been often described by $s^2 = (x^2 + y^2 + z^2 - c^2t^2)$. In this equation x, y, and z refer to the three dimensions or planes of space, c is the velocity of light and t is fundamental duration of a fundamental operation. The square root of this value for the typical three-dimensional metrics of the human brain and the typical temporal operation, the action potential (which is within the millisecond range), results in a negative number. This produces an "imaginary" or i solution that would require access to a real phase space that is difficult to describe (Koren & Persinger, 2002).

Instead, this article suggests that the inflection point where the product of the speed of light and the time are a value that results in a real solution could reflect the four-dimensional distance or fundamental metric of brain function. If it is assumed for convenience a functional volume 1728 cc for a cubic form of human brain (.12 m of space for each spatial plane), then the square of the x, y, z coordinates would be 4.32×10^{-2} m^2. Because the square of the speed of light in free space is constant (9×10^{16} m/s) the time course to cancel this value and result in net value greater than 0 (non imaginary) would be $.48 \times 10^{-18}$ s^2

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or .69 × 10^{-9} s. For an electromagnetic wave this time would be equivalent to a wavelength of .69 × 10^{-9} s × 3 × 10^{8} m/s or .207 m or 20.7 cm.

Hence, the threshold for the inflection in four-dimensional distance between imaginary i space and real space occupied by a human brain would require a wavelength equivalent to the neutral hydrogen (H) wavelength of 21 cm (1.4 GHz). This specific frequency is determined by the energy difference when the spin of the electron relative to its proton shifts from either parallel to antiparallel or vice versa. In free space (Wyatt, 1964) the ratio of time within the parallel compared to antiparallel state is 3:1.

Another solution derived for distance from the dimensional analyses of material occupying a volume, time, and the speed of light is $s = (s^3)/c^2t^2$. If the volume of cubic space occupied by the brain is 1.73 × 10^{-3} m^3 (.12 m in each plane) and it is assumed the operational time for an action potential is 1 ms (10^{-3} s) then the division of the product of 9 × 10^{16} m^2/s^2 and 9 × 10^{-6} s^2 (.81 × 10^{-12} m^2) would be 2.13 × 10^{-15} m, which is the approximate width of a proton or an electron). This congruence between the solution for "four-dimensional distance" being the wavelength of hydrogen and the solution for s^3/ c^2t^2 whose dimensional analyses results in length being the width of a proton or an electron again suggests pivotal roles of these fundamental units of matter in brain function within four-dimensional space.

INTEGRATION INTO ONGOING EXPERIENCE

This conspicuous congruence of solutions for variations of cerebral distance and both the emission frequency of free hydrogen and the width of a proton or an electron should be functionally relevant. Hydrogen comprises approximately 90% of the universe. More than 80% of the human body is water, the major constituent of which is hydrogen. It is suggested that the specific spatial boundaries, the volume, of the human brain may allow its access to some components or properties of this major constituent of the universe. From this perspective, the value of about 10^{-9} s to allow a real versus imaginary solution indicates that "information" from this "universal" frequency might be accessed into brain processes if there were sufficient spatial and temporal summations for this information to emerge within the increment of time (in the order of 10^{-2} s) associated with human consciousness and awareness.

The requirement for spatial and temporal summation of electromagnetic events, such as changes in local polarizations in the membrane, for the detection of a phenomenon is essential to brain function. Spatial and temporal summations of the multiple synaptic points or spines on the dendritic surface

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of a neuron contribute to the probability of the digital occurrence of an action potential (McFadden, 2002). In turn the temporal patterns of these action potentials determine the information represented and coded as experience. The usual range for temporal summation is between 10 ms and 20 ms (Edelman, 1989).

This discrete range is reflected at large spatial organizations in the timing of transcerebral and coherent electromagnetic waves that move in a rostral to caudal direction every approximately 10 ms to 20 ms (100 Hz to 50 Hz). These "re-entrant" processes have been argued by Edelman (1989) to be the derivatives that may be the experiences of awareness and consciousness and indicate that "consciousness" is composed of a series of "quantal" cerebral states (Llinas & Pare, 1991) rather than an unbroken stream of consciousness as described by many writers and experienced by most human beings. The sense of continuity occurs because the minimal increment of difference to discern "now," which is around 50 ms, exceeds the threshold of resolution (Calvin, 1996).

At smaller spatial organizations, the period between 5 ms and 20 ms also reflects the time required to donate and receive an electron between ubiquinone and cytochrome c. They carry electrons between the major enzyme complexes of the respiratory chain within the mitochondria where the oxygen molecule is maintained within copper-iron protein complexes to control the rate of the reaction (Alberts et al., 2002). Thus, from the level of the essential chemistry that supports the processes defining brain functions to the inclusive level of the entire cerebral cortical manifold the optimal increment of time for summation is of the order of 10 ms.

If these interpretations of the calculations are valid, then the information from large spatial increments of hydrogen sources would occur in temporal increments of about a nanosecond. For information within this duration to be incorporated into ongoing experience the summed, serial duration must be sufficient to be integrated into the 20 ms increments of neuronal process that define consciousness in the physical world (Jahn & Dunne, 1987). To construct a 20 ms interval about 10 million of these 10^{-9} s increments would required. However, it is suggested that the information with much briefer durations could enter the cerebral process during those small but discrete temporal increments between the termination of one rostral to caudal transcerebral wave and the initiation of the next (Tsang et al., 2004).

In some philosophies this time for these successive "quanta" of consciousness has been called variants of "the infinitesimal infinite" because the process ("consciousness") does not exist during that time. If the hypothesis

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developed in this article is supported, then information from substantially different space-time sources could occasionally enter into awareness during these temporal interfaces between successive "quanta" (Booth et al., 2005). The experiences would be integrated within the other typical information that compose the stream of consciousness of the experient and, unless the corresponding images or feelings were markedly noncongruent, would be considered a part of normal cognition (Tononi & Edelman, 1998).

ABSOLUTE EXPANSION

Any intrinsic dynamic within the physical substrates of matter occupying brain space could affect how electromagnetic fields might interact with the matter. If the universe is expanding then the units of matter and space would be expected to expand in some systematic manner. Although there is no direct evidence that the expansion would be either continuous or discrete, it is assumed that any continuity is composed of discrete increments of space. They can only be inferred because to measure the smallest discrete increment would require a smaller increment (delta t) whose value was at least twice as small (or one-half the increment) or no change would be detected. In many sciences this is defined as the Nyquist boundary.

The smallest increment of space, 1.6×10^{-35} m (Planck's length) was derived by the appropriate dimensional analyses of the three fundamental constants: Planck's constant (h) of 6.62×10^{-34} J s, the gravitational constant (G) of 6.67×10^{-11} N m^2/kg^2 and the velocity of light (c). The metric is the solution of the equation s (distance) = sqrt of hG/c^3.

The range in expansion according to Hubble's constant is between 50 and 100 km/s per Mparsec (3.1×10^{22} m) or 1.6×10^{-18} s^{-1} and 3.2×10^{-18} s^{-1}, respectively. For the intermediate value of 75 km/s the value is 2.4×10^{-18} s^{-1}. The velocity of expansion for any matter occupying space would be this value multiplied by the width of the space. The coefficients for the minimum and maximum values would be $v_{min} = 1.6$ and $v_{max} = 3.2$, respectively.

The length of a proton is assumed to be 2.6×10^{-15} m (twice the Compton radius or wavelength). For a proton the velocity of expansion, based on the intermediate value of Hubble's constant would be 8.32×10^{-33} m/s. The time to expand one Planck's length would be 1.6×10^{-35} m divided by 8.3×10^{-33} m/s or about 2.6 ms ($v_{min} = 2.0$ ms; $v_{max} = 4.0$ ms). If one approached the problem using the radius (1/2 the length in the tradition of solutions for some antennae) of a proton, the range would be 4 ms to 8 ms.

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For comparison, the velocity of expansion for electrons to expand one Planck's length would be 4.86×10^{-15} m (twice the radius) $\times$ 2.4×10^{-18} s^{-1} or 11.66×10^{-33} m/s. This would be equivalent to an increase by one Planck's length for every electron every 1.4 ms ($v_{min} = 1.0$ ms; $v_{max} = 1.8$ ms). If the electron radius (employing either the classical value or the Compton wavelength) is considered the solutions for the time required to expand one Planck's length would range between 2 ms and 4 ms.

Transfers and transport chains of protons and electrons are intricately interdependent and form the bases of all major biochemical reactions that range from oxidative reactions to the maintenance of reactive oxygen species such as nitric oxide (NO). While electron transfers release large amounts of energy, protons flicker through the matrix of hydrogen-bond water molecules through serial associations with adjacent molecules. The proton plays a special role in electron transport by neutralizing molecules reduced by acquiring an electron. This results in the transfer of an entire hydrogen atom. These dynamic processes require discrete increments of time and if they occur as particular temporal patterns they could be affected by the appropriate pattern of magnetic fields.

These increments of time for the authors' solutions for protons and electrons are within the range of the point durations employed in the present experiments to produce the maximum biological effects when complex magnetic fields are generated through the organism's biological space (Martin et al., 2004, 2005; Persinger, 2003). The authors generated the experimental magnetic fields by serially converting one of 256 values between 0 and 255 to equivalent increments of voltage (-5 V to $+5$ V). The conversion is from a column of numbers in a computer program through a digital-to-analogue converter (DAC).

The output from the DAC is then sent to the appropriate configurations of electric current that define the spatial parameters of the magnetic field to which the organism is exposed. These configurations have included Helmholtz coils, turns of wire with widths much larger than their lengths, matched coils with bulk functional "positive" and "negative" connections that are in phase or out of phase, and various combinations of solenoids within either one, two, or three spatial planes.

The point (or "pixel") duration, the time each specific voltage associated with a number between 0 and 255 is generated, is controlled by computer software and has ranged between 1 ms and 10 ms in most of the experiments. With this procedure one can generate any complex sequence of magnetic fields. If one imagines the horizontal axis being the point duration for each value and

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the vertical axis being some value between −5 V and +5 V, then the temporal configuration for 1 s employing 1 ms point durations would be potentially 256^{1000}, although resolution and the issues of inductance and reluctance would strongly influence the final number of biologically relevant combinations.

If the hypothesis is correct then even very weak forces or forces applied over spaces (energy), if resonant with the intrinsic expansion of matter, could affect the "fabric" of organismic space and alter its function through direct modification of processes emerging from the proton (or the electron) itself. For the proton the time increments of 2 ms to 4 ms corresponds to frequencies between 250 Hz to 500 Hz. For the electron the increments of between about 1 ms and 2 ms would be equivalent to frequencies between about 0.5 kHz and 1 kHz.

These changes define the typical parameters of action potentials, the mode by which the faster forms of complex information is propagated within brain space. The classical durations for the durations of the major component of the action potential are between 0.5 ms and 1.5 ms. This band also defines the fast ripple frequencies (Bragin et al., 2002, 2003) that appear to be common to neurons within the cerebral cortices of the rat and the human brain and might define a fundamental property of cells specialized for this form of irritability.

The solution for the time to expand one Planck's length varies with level of discourse or increment of space. The length or diameter of a hydrogen atom is 74 picometers. From the earlier equations the velocity of expansion would be 177.6×10^{-30} m/s. To expand one Planck's length would require 1.6×10^{-35} m divided by 177.6×10^{-30} m/s or 9.3×10^{-8} s or 93 ns (range = 67 to 135 ns). The equivalent frequency would be 11 MHz with a range between 15 MHz and 7 MHz, respectively. The corresponding values for lengths occupied by biological phenomena such as the membrane (10 nm), organelles within cells such as mitochondria (1 micrometer), cells (10 micrometers), organization of cellular networks within the cortices (1 mm), organs (10 cm), and organisms (1 m) are shown in Table 1.

However, a potentially important value emerges from the relationship between the time required to expand one Planck's length by any length of space and matter. In general for 10^{-15} m space, 10^{-3} s was required, for 10^{-12} m space, 10^{-6} s was required. As shown in Figure 1, the relationship displays an inflection point around .3 nm and 30 ns for the mean value for Hubble's constant. This length corresponds to about 1×10^{18} Hz, a frequency band occupied classically by X-rays. Most of the power within this first derivative occurs between .1 and .5 nm with intervals of between 10 and 55 nanos when the minium and maximum values are included. This value is within the duration

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Table 1. The values for the time required for expansion of one Planck's length at each length of space for biologically relevant distances, the equivalent frequency, and the electromagnetic wavelength for the median value of Hubble's constant

Length Phenomenon	Time (s)	Frequency (Hz)	$Wavelength_{em}$
1 fm proton	0.66×10^{-2}	149 Hz	2 Mm
1 pm atom	0.66×10^{-5}	149 kHz	2 km
1 nm ion channel	0.66×10^{-8}	149 MHz	2 m
10 nm cell membrane	0.66×10^{-9}	1.49 GHz*	0.2 m
100 nm organelle	0.66×10^{-10}	14.9 GHz	2 cm
1 um organelle	0.66×10^{-11}	149 GHz	2 mm
10 um cell	0.66×10^{-12}	1.49 THz	0.2 mm
100 um cell cluster	0.66×10^{-13}	14.9 THz	20 um
1 mm axon length	0.66×10^{-14}	149 THz	2 um
1 cm organ	0.66×10^{-15}	1.49 PHz	0.2 um
10 cm large organ	0.66×10^{-16}	14.9. PHz	20 nm
1 m organism	0.66×10^{-17}	149 PHz	2 nm

*Absorption for hydrogen is 1.48 Ghz and would be equivalent to 73.408 km/s/Mpc for Hubble's constant.

(about 10^{-8} s) a hydrogen electron lingers in an outer orbit before returning to ground state.

This particular convergence between the increment of time and the increment of space is also the transition point between the lengths occupied

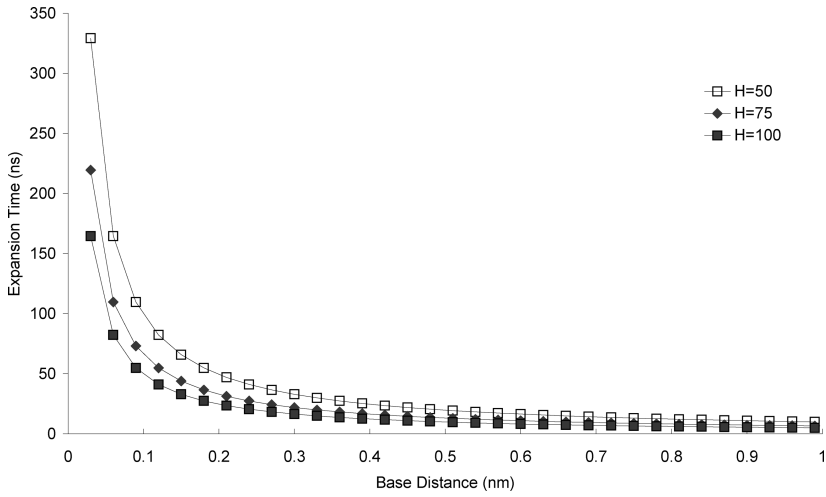

Figure 1. The vertical axis is the time required for a base distance (horizontal axis) to expand one Planck's length based on Hubble's constant. The values for each of the three curves indicate solutions for the minimum and maximum values (50, 100 km/s/Megaparsec) of the constant as well as the median value (75 km/s/Mpc).

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by biologically relevant atoms, whose radii range between.037 nm (H) to.227 nm (potassium). This increment is also congruent with that for the distance of the various types of chemical bonds that include the covalent (.15 nm), ionic (.25 nm), and hydrogen (.30 nm) forms as well as van der Waals attractions (.35 nm).

However, perhaps more importantly this convergence also occurs within the narrow band of space occupied by the base nucleotides that compose the core of deoxyribonucleic acid (DNA) and its variants. These fundamental molecules construct the spatial organization of the more or less stable digital sequence of base pairs containing the genetic history of life forms on this planet for the last approximately 3 billion years. This increment of space and time is also a nodal region for the digital sequences that control the structure and lifetime of the individual organism.

The second interesting concurrence of values occurs for distances of 10 nm, the approximate and often averaged width of the most important boundary condition in living systems: the membrane. According to the solutions, the resonant time for a 10 nm space would be about 0.6 ns and the corresponding frequency would be 1.52 GHz. This is almost identical to the absorption frequency for H, a value that would clearly be included if the entire range of Hubble's values was considered. Working conversely, if the solutions are valid, the specific frequency known for H absorption (1.48 GHz) would predict that the true average value for Hubble's constant would be 73.408 km/s/Mpc. Verification of this value or its close approximation by the most modern measurements would help support the intrinsic validity of the present approach.

The electromagnetic wavelength for 1.52 GHz is. 2 m or 20 cm, which translates to the range of the circumference of a human skull (63 cm). These solutions indicate that a resonant wavelength associated with the successive expansion of Planck's length in membrane (10 nm) space is the diameter of the human brain. Both the frequency and the electromagnetic wavelength overlap with the absorption frequency for hydrogen. The obvious hypothesis is that this narrow GHz band pulsed at between 0.1 and 1 ns through the brain should produce resonance with or access to information contained within the hydrogen matrix.

There are also two relationships between the length of space considered for the expansion and the associated electromagnetic wavelengths. In Table 2 there is clearly a switch over in values within the micrometer range. The intersection of the slopes occurs at 75 um (for v_{med} of Hubble's constant). Considering the range in values of Hubble's constant this value is within the width expected for the emergence of the Goldstone boson from the quantal to macro level

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Table 2. Relationship between the length of space involved in the calculations and the associated electromagnetic wavelength assuming the velocity of light

Length (microm)	Wavelength (microm)
10	200
20	180
30	160
40	140
50	120
60	100
70	80
75	75
80	60
90	40
100	20

as electromagnetic energy within the range generated by the cerebral cortices (Jibu & Yasue, 1995).

For the median value this is equivalent to a frequency of 4×10^{12} Hz (4 THz). This wavelength would be the peak value from a black body of 38.7°K or −234.4°C as calculated by Wien's Law (.29 cm-°K/°K). Because the temperature of the cosmic background is about 2.73°K and that interstellar neutral hydrogen is at a temperature of about 100° K (assuming the average number density in our part of galactic space is about one hydrogen atom per cc), the value of 38.7°K suggests a less dense value (in the order of one hydrogen atom per m^3) or some other critical parameter hereto undetected.

The relationship between wavelength and temperature and the emergence of a space occupied by essential biological phenomena may have multiple examples hereto unexplained or attributed to other sources. For example the human body, like most mammals, maintains a temperature of 37°C or 310°K. According to the results of Wien's law the maximum wavelength for this property of (biological) space would be 9,350 nm or 9.35 micrometer, which is well within the range of the width of the generic cell. If one assumed even a first order normal distribution of both the wavelengths around the maximum value predicted by Wien's law for 37°C and the predicted average width of a cell, most of the widths of the approximately 10^{13} cells (a substantial number being the 7 micrometer erythrocyte) within the human body would be accommodated.

The second potentially useful principle of function that emerges from this relationship is for the electromagnetic wavelengths between 400 and 800 nm

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(visible light) and the respective length of space associated with it. For 400 nm, 600 nm, 800 nm the values for the length space that is expanding would be 9 mm, 8 mm, 7, mm, and 6 mm, respectively. For the near infrared, the wavelengths of 1000 nm, 1200 nm, and 1400 nm, would involve distances of 5 mm, 4 mm, and 3 mm, respectively. These characteristics of coherent photons, including their capacity to store information and to form gene-specific photons, are similar to those predicted by Popp (1979).

The article suggests this "relationship" between wavelength and length of space would reflect some form of propagation. Therefore, for 600 nm wavelengths the distance of functional connection or propagation would be 8 mm. For 800 nm to 1000 nm (the near infrared), the propagation distances would be 6 to 7 mm (slightly greater than the depth of the human cerebral cortices). This would imply that a biological space of 1 microm (1000 nm), the domain of mitochondria, could propagate information to distances approximately 6,000 times further than its functional width.

If this approach is valid, then to produce the maximum effect of applied complex magnetic fields, the temporal configurations of the fields must contain information embedded into multiple patterns that can interact at more or less the same time within *each* of the levels of discourse from the level of the proton and electron to the entire organism. The simultaneous stimulation *across* levels of space and increments of time by patterns embedded within patterns within the applied fields might be described metaphorically as aligning the multiple tumblers in a lock or reconfiguring a lattice such that all relevant levels of space are resonant at the same time. Within this condition, a variant of a "condensate," minimum energies should be required to alter all of the levels of space within the brain. That cells and enzyme systems can respond to stacked complexities of electromagnetic fields through "temporal sensing" has been shown by Litovitz et al. (1997).

ESTIMATING LEVELS OF SPACE

Whether the existence of levels of discourse are independent or dependent on human perception is not important for relating the processes and energies that intercalate cellular activity to the functions of organs or molecular movements to the functions of cells. The coupling or equivalence between levels of discourse should involve quantitative, measurable, and describable mechanisms that once replicated experimentally should allow direct access to processes through the smaller and smaller increments of space. This assumption has been, in general, supported by the success of molecular biology.

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As discussed by Persinger (1999) there appears to be a more or less linear relationship between the increment of space (an event or object) that is being observed and the increment of time to be observed in order to discern the object or event ("statics"). The increment of time to discern a phenomenon as dynamic, such as a process ("kinetics"), must be at least 1/2 the value for the increment of time displayed by the phenomenon. If the increment of time is too wide there could be overinclusion of unrelated events. If the increment is too small, then the phenomenon may be obscured by the numbers of intervals.

For example, the optimal increment of measurement to observe an action potential whose duration is 1 ms is approximately 0.1 ms to 0.5 ms. If picos increments of time are employed there would be a billion units of time required to detect a single action potential. The slope of this "all-or-none" change would approach zero and the "spike" would not be discerned. On the other hand if 1 s increments were employed a large number of action potentials would be summed as a single observation. Attempts to replicate the magnitude of the phenomenon would appear to be "inconsistent" or "too variable" because multiple but variable numbers of events, even though they were qualitatively identical, were overincluded.

Traditionally, the levels of discourse that define the different biologically related sciences are organized in increments of approximately 10^3. They include the organism (1 m), the organ 10^{-3} m, the cell 10^{-6} m, the membrane 10^{-9} m, the atom 10^{-12} m, and the basic particles like the proton 10^{-15} m. However, if a quantum neuroscience is to be exhaustive in the pursuit of possibilities, the remaining possible spaces must be considered. If the shortest length is Planck's length of 1.6×10^{-35} m, then the difference between the traditionally smallest level of discourse (the proton, electron) and the smallest possible length is 10^{20}.

As a first approximation, assuming that differences in the division and multiplication of coefficients will occupy at least one order of magnitude, this discrepancy would allow the existence of *seven* more levels of discourse or organizations of space or the hidden factor to which it is related. The inference of seven more levels or dimensions for a total of eleven-dimensional structures is consistent with the estimates from various traditions of the theories from the early nineteenth century physicists Kaluza and Klein (Freedman & van Nieuwenhuizen, 1985) who postulated these extra dimensions to unify fundamental forces.

The number of eleven dimensions arises from a mathematical coincidence whereby theories of "supergravity" can be formulated in any number of space-time dimensions as long as the number is less than 12. For the traditional Kaluza-Klein theory the additional seven dimensions are assumed to be curled

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and physically real but simply unseen. They can accommodate the essential dichotomy of elementary particles, which include the bosons that carry and transmit fundamental forces and the fermions (such as the proton, electron, neutron) that compose the bulk matter of the universe.

Even if it was naively assumed that what is now described as strong nuclear forces (10^{-18} m), weak nuclear forces (10^{-21} m) electromagnetism (10^{-24} m), and gravity (10^{-27} m) occupy four of these organizational levels, three more would remain that might reflect configurations not currently conceivable or perceptible. The results of these calculations produce a potential paradox where by the larger the space the shorter the duration of time to expand one Planck's length. The time required to expand the smallest value greater than Planck's length approaches the age of the universe. On the other hand the time for the estimated width of the universe (about 10^{26} m) to expand one Planck's length is about 10^{-27} s. This latter value is within the range often considered to be the timeframe required for the formative stages of the "Big Bang."

PROTON VOLUME AND A "PLANCK STRING" LENGTH

The importance of the spatial and temporal configurations that satisfy those occupied by the proton and the electron (and implicity the addition of the two, the neutron) as solutions for the potentially optimal values for generating complex magnetic fields that affect brain volumes should be reflected in other properties consistent with the derivations in the previous section. If the other "seven" dimensions are real within subatomic space then basic geometric solutions that accommodate these assumptions should yield empirical values matching the maximum values generated by employing the "smallest" possible increment of time.

There is direct support for this inference. The volume of a proton is about 10^{-45} m^3. If it is assumed the proton was a sphere with an eccentricity = 0 but was then distended to an eccentricity = 1 (effectively a long tube), the volumetric description would be pi r^2 l (length). From the present approach the smallest spatial increment is Planck's length or 1.6×10^{-35} m. The cross-sectional area of this small "tube" or "string" would be 10^{-70} m^2. The length that would be required to produce the full volume of the proton would be 10^{25} m, which is the estimated width of the known universe assuming it has existed for 10 billion years and the velocity of light has not changed.

In other words, if a "Planck-length string" were curled within a single proton, the length of the string would be the width of the universe. From this perspective what is perceived in four dimensions as discrete space-time points

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called protons and electrons in very small space may actually represent the fabric comprising the length of the entire universe. Two obvious questions arise: Could some specific access to the process that organizes the "Planck-length string" that *is* the proton allow access to the extent of the universe in space and time? What critical values of amount and duration of the information contained within these strings would be required to emerge into awareness and potentially be labelled as a conscious experience?

Because the volume of an electron is similar to that of a proton the estimated metric of the "Planck-length string" would also approach the width of the universe. If the Planck-length string assumption is correct, then the differential mass of the electron and proton would be related systematically to some process associated with the differential volume of the two. This assumes the larger measured width of the electron is not an error of measurement due to the classical uncertainty principle. Its velocity of axial rotation may add to its orbital motion and result in a "blur" that inflates the estimated length because of the more significant contribution of time to the metric.

INFORMATION CONTAINED WITHIN BRAIN SPACE

If one assumes information is primarily a series of digits with values of either 0 or 1 (a bit) and their increment of space is coordinated with the increment of time one could potentially calculate the total information contained within brain space. The authors have assumed that this smallest increment of 0,1 is Planck's length, that is 10^{-35} m, and it exists for a similar length of time (about 10^{-35} s). [The magnitude of the difference between this value and Planck's time, which is between 10^{-44} s to 10^{-43} s, is effectively the magnitude of the velocity of light, a fundamental base, that will be discussed elsewhere.] This length can be considered the minimum for the mathematical limit of the underlying process that: (1) either integrates all of space-time through all levels of discourse, or (2) is the source from which levels of discourse simply sample discrete increments of space and time.

We assume that the maximum numbers of divisions of a Planck's string that could contain information would be a series of 0 s and 1 s each with a radius and length of the value of Planck's length (10^{-35} m) such that the volume of a Planck's "bit" would be 10^{-105} m^3. It would be analogous at more macroscopic levels to the string of nucleotides in a sequence of RNA in space or a string of action potentials (1 ms in duration) along an axon over time. That processes in time, such as the action potential, and events in space, such as the addition of a nucleotide to a ribbon of RNA, can be energetically equivalent and intercalated

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was reiterated by Wei (1969). For example the energy produced by a change of 120 mV (from the −70 mV resting potential to the +50 mV overshoot during the peak of the spike) on each net charge would be 1.2×10^{-1} V $\times$ 1.6×10^{-19} Coulombs or about 2×10^{-20} J, which is equivalent in order of magnitude to the stacking energy of a single base pair. Both phenomena require about 1 ms.

From this perspective the maximum amount of potential information per approximately 100 ms or 10^{-1} s (where awareness becomes consistent) from a single Planck's string would be 2 to the exponent of 10^{34} bits. If it is assumed that the volume of the brain is 10^{-3} m^3 then there would be approximately 10^{-3} m^3 divided by 10^{-105} m^3 or 10^{102} Planck's bits within brain space. This means that the simple upper boundary (not including interaction between the strings) for information contained with brain space-time, even assuming Nyquist requirements for resolution, would be the very large number of the product of 10^{102} multiplied by 2 to the exponent of 10^{34}.

For values from the level of the proton, where the increments of space are 10^{-15} m and time are 10^{-15} s, the amount of information per 100 ms would be 2 to the exponent 10^{14}. This value would refer only to a single increment of space and would be multiplied by the numbers of these increments within brain space. For the proton, whose volume is approximately 10^{-45} m^3 the numbers of proton volumes that could fit within 10^{-3} m^3 of brain space would be 10^{42}. This means the simple information, assuming no redundancy between "proton volumes," would be the product of 10^{42} and 2 to the exponent of 10^{14}.

However, the mass of the brain is about 1.5 kg and if one proton weighs 1.6×10^{-27} kg, then the numbers of protons (the weight from electrons being negligible) would be 1.5 kg divided by 1.6×10^{-27} kg or about 10^{27}. This value indicates that, even when considering the contributions from electrons and assuming a match between the numbers of protons and neutrons (that would not affect the order of magnitude), protons, neutrons, and electrons occupy less than one part per quadrillion (10^{-15}) of the potential "proton volume" space within the brain.

The value of 10^{27} proton equivalents multiplied by 2 to the exponent 10^{14} femtos per 100 ms increment of consciousness still yields an enormous information capacity based on the available "protonbits" within brain space. This value does not include the contributions from higher order combinations between protonbits. If the protons (and electrons) are actually Planck strings coiled within a small space but whose ultradimensional extension are actually very long lengths approaching values for the diameter of the universe, then the amount as well as the *extent* of the *potential* information would be substantial.

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However, the resolution of a bit of information at the next level of any of the discourses or spatial increments would share one requirement. The occurrence of a 0,1 at the greater increment of space would require either a majority of 0 s or 1 s within the base rate. The more either the 1 s or 0 s predominated a temporal string the more definitively the bit can be discerned at the next level of discourse. For example for information from the level of Planck's length (10^{-35} m) to be digital within the level of the proton (10^{-15} m) more than 0.5 of the 10^{20} increments must be either all 0 s or all 1 s.

This requirement for an inordinate string of either 0 s or 1 s, with the mixture and complexity that defines information suggests that the smallest levels of discourse must show a maximum entropy. In this instance maximum entropy is defined as the occurrence of all of one value or the other value within a basic string such that the averaging of all strings results in an average value. From this perspective entropy would not be a process necessarily converging from the largest areas of space but would be originating from the smallest increments of space-time and "percolating" upward into larger and larger spatial organizations.

However, the occurrence of a vast reservoir of 0,1 units, the basis of information, does not necessarily transform to the type of repetitive space-time *patterns* (such as the similarity between the sun and its planets and the nucleus and its electrons) that emerge within the various levels of discourse. One would expect the existence of basic gnomons. They are forms that, when added to some form, result in a new form similar to the original (Gazale, 1999). The existence of gnomons would allow specific continuities in patterns of organization of matter and energy from the smallest to largest increments of space. Access to these patterns of organization could allow significant alterations in the spatial arrangement of space and hence the shape of matter with very minimal energy. These values should be minuscule compared to the magnitudes of approximately 10^{17} J required to transform 1 kg of matter into energy or energy into matter.

These forms, particularly those that involve temporal patterns derived from iterative processes, might be considered the intrinsic resonances through which applied electromagnetic fields might access the various levels of spatial organization within the brain. It may be relevant that the fractal dimensions of Mandlebrot, the Fibonacci sequences, and periodic continued fractions, leading to whorled figures, are ultimately composed of series 0,1 s ("pixels"). The occurrence of these repetitive patterns of space and their associated temporal patterns (Persinger, 1999) suggests a potential by which the similarities between levels of discourse might be explained. Experimental isolation of these "keys" might allow access to information maintained within the smallest increments

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of the volume occupied by the human brain that reflects the characteristics of much larger extents of space and time. We now have the required technical complexity to generate these "keys." The next step is to isolate their sequences.

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